

An Introduction to Synthetic Biology

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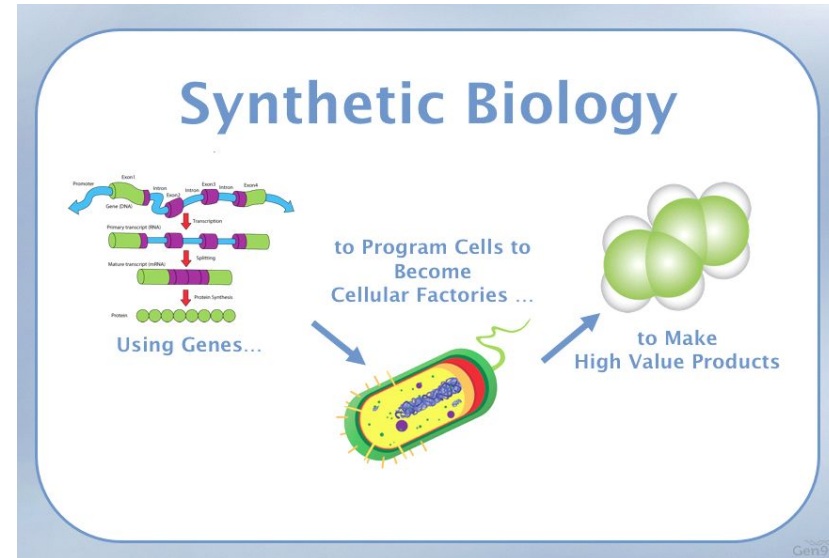
Talking Points

- What is Synthetic Biology?
- How does it work?
- Applications of genetic engineering
- Benefits of GMOs
- GMO Misconceptions
- iGEM

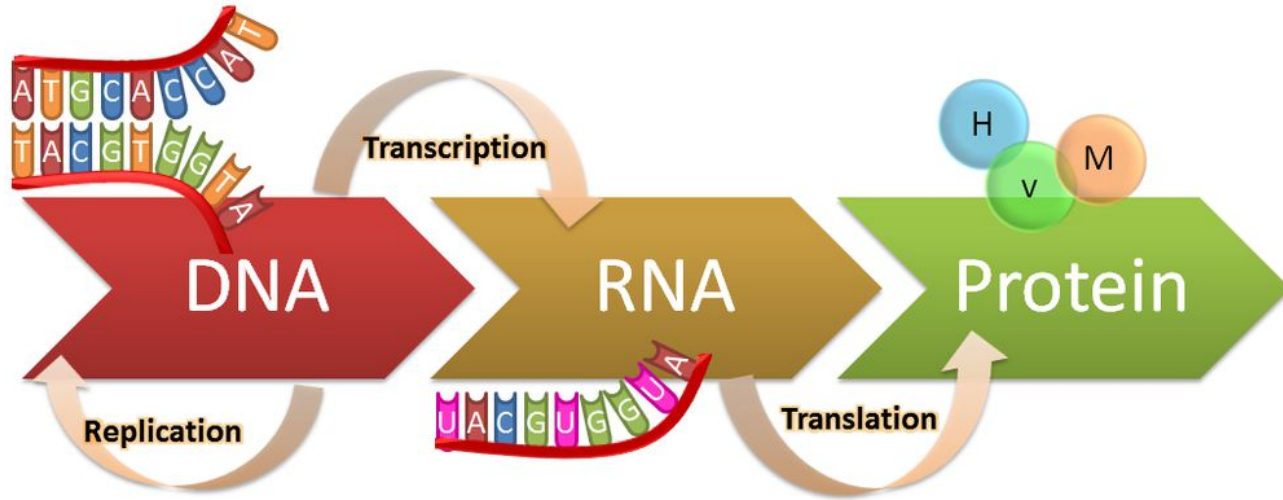
What is Synthetic Biology?

What is synthetic biology?

- Applying an engineering and computing mindset to biology
- Looking at organisms as if they were machines and breaking them down into parts that can be rearranged to carry out new functions



Central Dogma of Biology



What is genetic engineering?

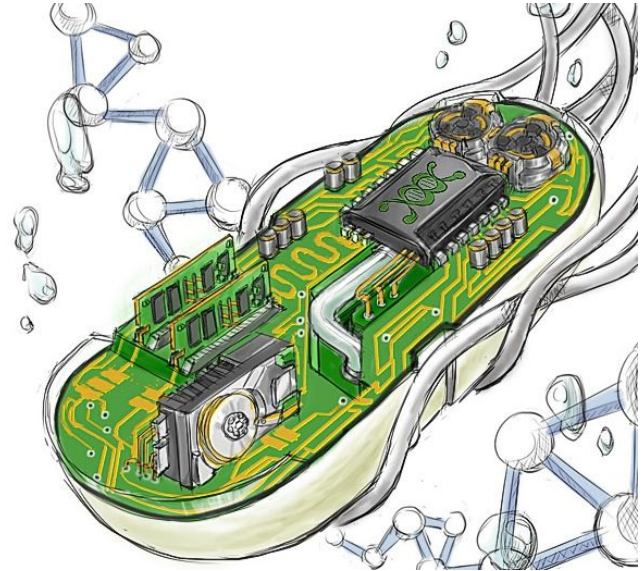
- Modifying the genome of organisms
 - Create proteins with novel functions
- Widely used in agriculture and medical research



How does it work?

Methods of Recombinant DNA Technology

- Inserting new genes into an organism
 - Restriction enzymes
 - Microinjections
 - Gene gun
 - CRISPR / Cas9



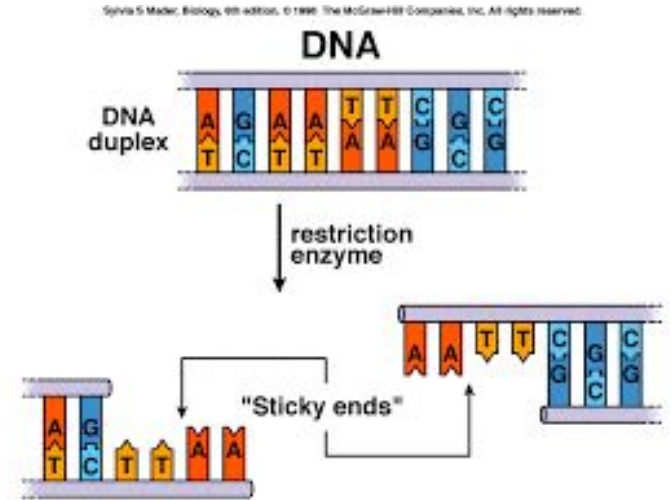
Recombinant DNA

Cutting and pasting DNA back together

Restriction enzymes = scissors - cuts a specific sequence (restriction site) of nucleotides and leaves sticky ends

Ends can overlap with parts of other DNA

Ligase = glue, puts strands back together - either same two strands come together or other strand with same restriction site



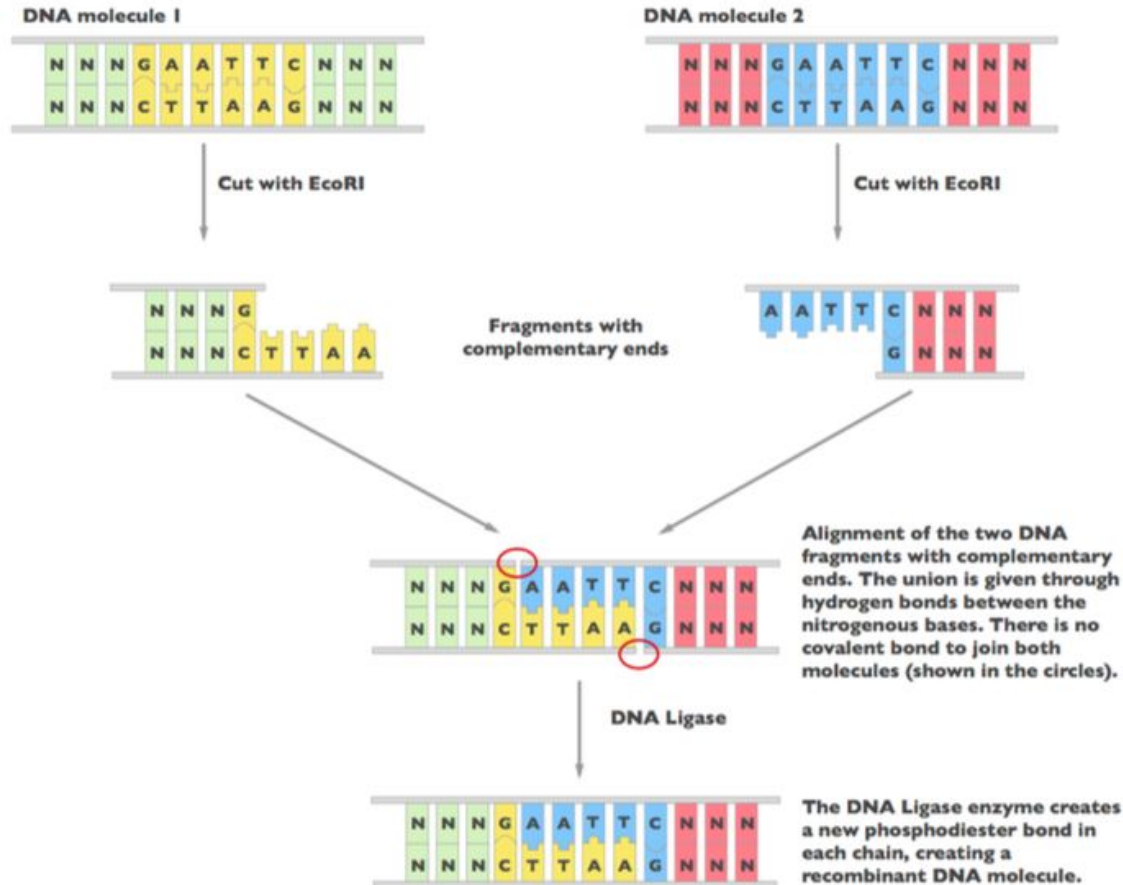
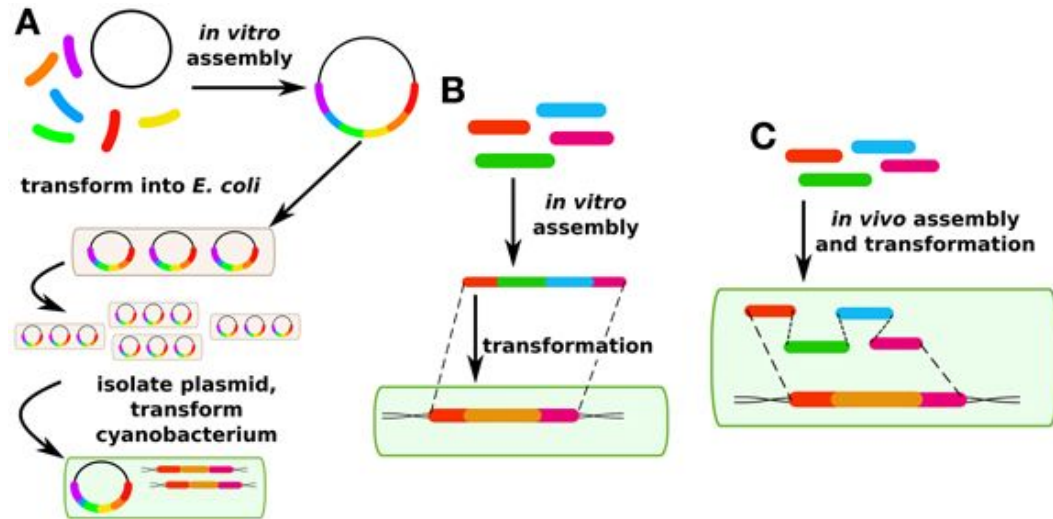


Figure 2.5. Construction of a recombinant DNA molecule through the use of compatible ends generated by the restriction enzymes and the union through DNA ligase.

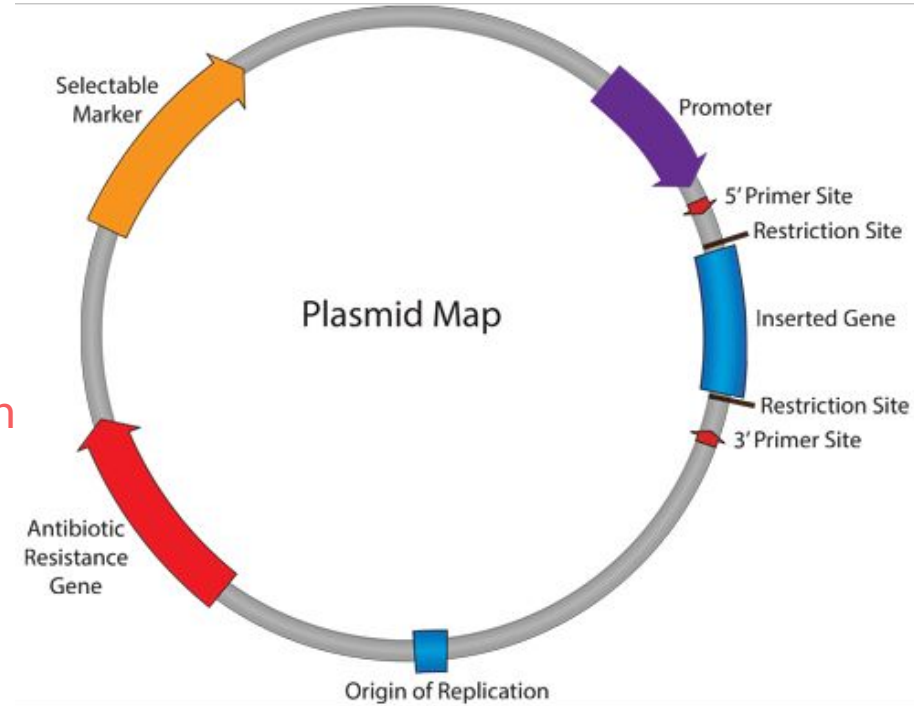
Recombinant Plasmid

- Plasmid = piece of circular DNA in bacteria, not chromosome
- Can replicate independently of bacterial chromosome
- Used as vehicle for introducing new genes into bacteria



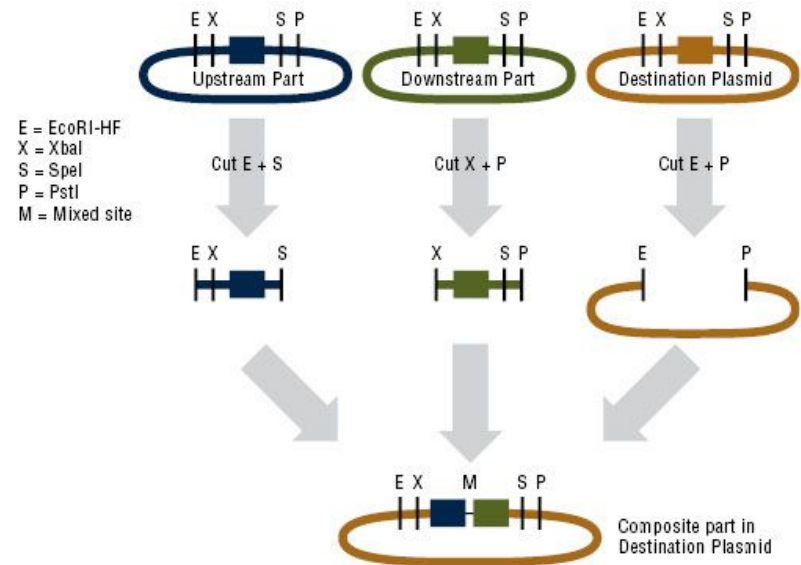
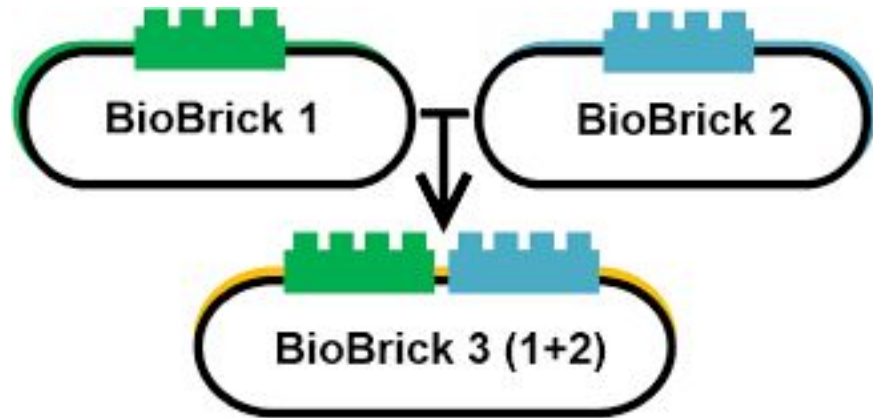
Components

- Origin of replication
- Restriction sites
- Regulatory sequence
- Promoter
- Transcription initiation and termination sequence
- Selectable marker - ex) antibiotic resistance



BioBricks!

- Preassembled genetic parts that have a specific, tested function
- Like Legos!



Applications of Genetic Engineering

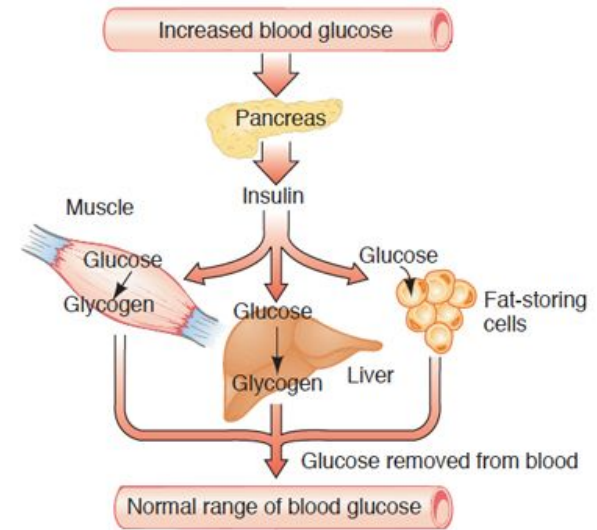
Problem: Diabetes

- Patients do not produce insulin or cannot use insulin efficiently
- Leads to high levels of glucose in blood
- Can lead to high blood pressure, kidney disease, or stroke



Solution: Use bacteria to produce human insulin!

- How?
 - The human insulin gene has been identified
 - Gene is inserted into plasmid
 - Plasmid multiplies in bacterial cell, cells reproduce
 - Bacteria produce human insulin proteins
 - Insulin is gathered and purified
- Millions of people with diabetes now take human insulin, produced by bacteria, that is genetically compatible with their bodies



Problem: Vitamin A Deficiency - VAD

- Common among third world countries
- Can cause blindness, compromised immune system, and even mortality
- The building block of vitamin A is beta carotene

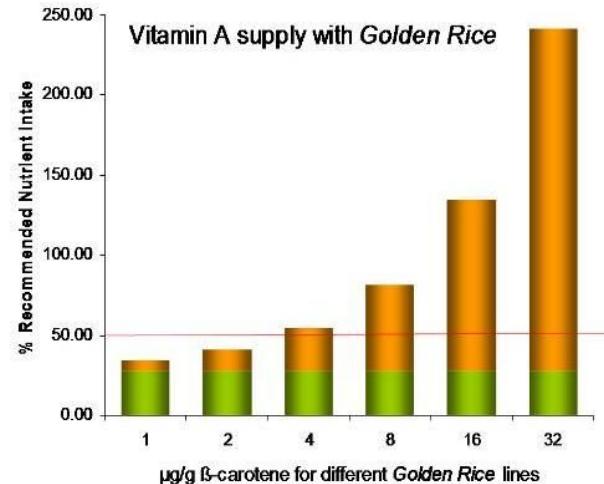


Golden Rice



Solution: Golden Rice!

- Rice is a common food source with a high caloric content but does not provide many nutrients
- Genetic modification of the rice plant to produce and accumulate beta carotene, which the body converts into Vitamin A!
- Metabolically engineered



Another Cool Example: Goat Spider Silk!



- Spiders have two key genes for weaving silk
- Genes inserted into goat genome next to a casein promoter (casein is a protein found in milk)
- Resulting proteins harvested through milk and extracted

Benefits

Benefits of GMO's

Agricultural Benefits are abundant

1. Higher nutrient content
2. Stronger - better at withstanding weather fluctuations
3. Resistance to disease
4. Insect resistance - less need for pesticides, especially the more toxic ones
5. Larger production - easier to raise
6. Require less tools and chemicals - more efficient



Common Misconceptions

1. GMOs cause cancer, allergies, and other health issues.

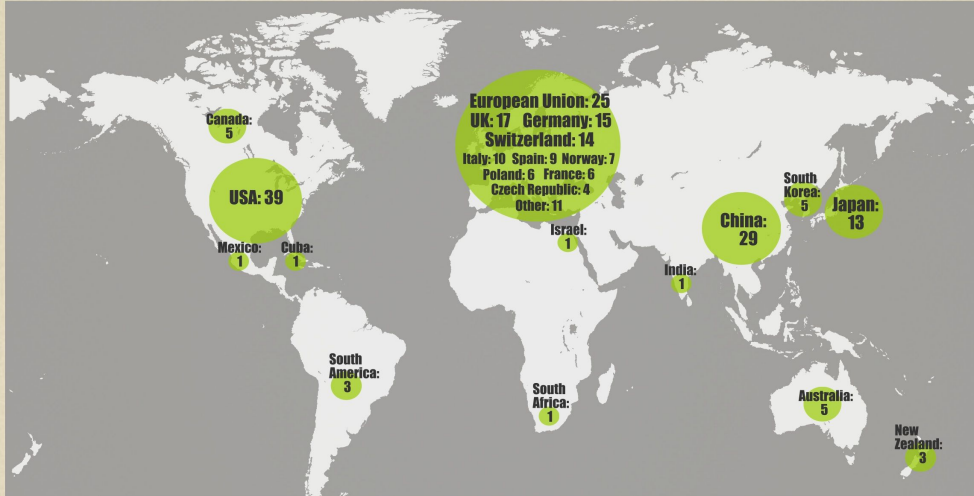
- Biotech companies do extensive allergy and toxicity testing.
- Most studies on genetically modified crops have shown no negative impact on health.
- Some studies concluding GMOs cause cancer were not well conducted and no comprehensive sets of data corroborated it.

2. Big Ag owns all research on GMOs.

There are hundreds of independent researchers working with GMOs.

Government-funded GMO studies around the world

Are the claims that GMO studies are only conducted in the U.S. true?

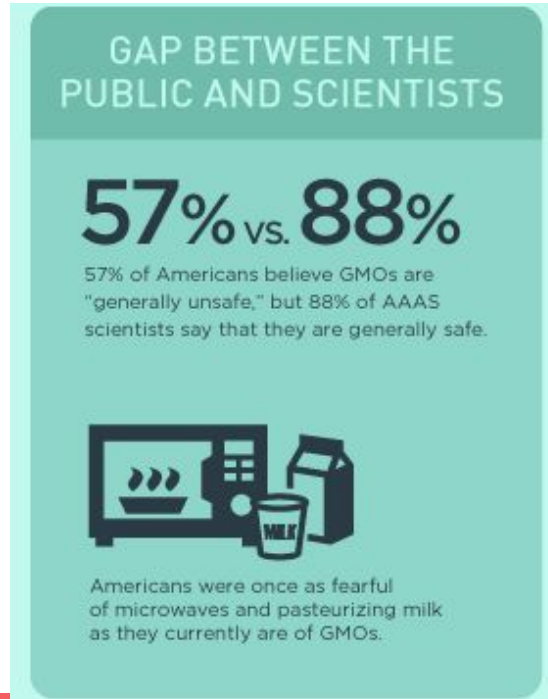


Data from the GENetic Engineering Risk Atlas (GENERA), showing 198 peer-reviewed scientific studies that address the risks and benefits of genetically engineered foods funded by governments worldwide out of 400 randomly selected for the beta release of the Atlas.

Visit genera.biofortified.org for up-to-date information.
Information presented in this graphic is accurate as of August 2014.

3. GMOs contain toxins.

The most common toxin in GMOs targets pests, not humans, and it is much safer than the chemicals that would be used otherwise



4. Dangerous genes from GMOs will spread and cause problems.

- The amount of gene transfer from plants to microorganisms is too low to cause concern
- More dangerous modifications, like antibiotic resistance, are avoided

How we're involved

iGEM

- International
- Genetically
- Engineered
- Machine



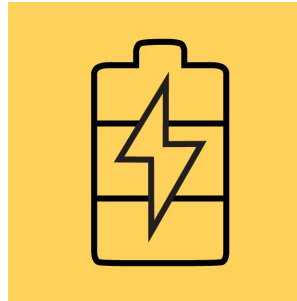
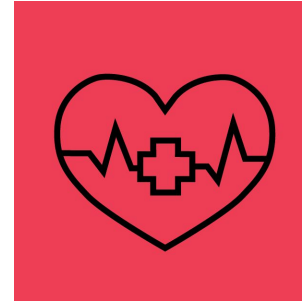
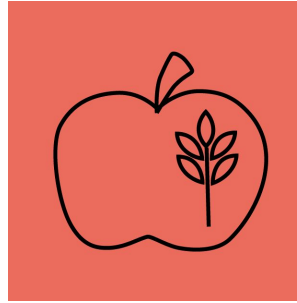
What is iGEM all about?

- **What:** Competition to make new genetically engineered systems
- **Who:** High schools and Universities
- **When:** Project work ongoing, competition takes place in late September
- **Where:** Work is done in wet labs and office space, competition takes place in Boston
- **Why:** Advance the field of synthetic biology, give students a chance to develop innovative thinking skills and problem solving.

What type of projects are developed?

Different tracks

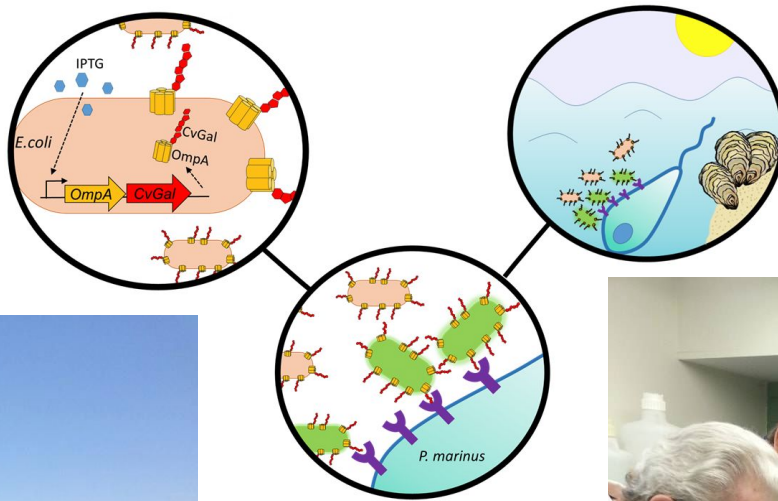
1. Energy
2. Environment
3. Food and Nutrition
4. Foundational Advance
5. Health and Medicine
6. Information Processing
7. Manufacturing
8. New Application



Our iGEM Team



Oyster project



How YOU Can Get Involved

- Start a high school iGEM team!
 - Great leadership experience
- Look to join a college team when you get to college!
- Consider a career in synthetic biology!



End

Thank you!

Any questions?